A NEW BLIND *PHYSA* FROM WYOMING WITH NOTES ON ITS ADAPTATION TO THE CAVE ENVIRONMENT

R. D. Turner and **W. J. Clench**

Museum of Comparative Zoology
Harvard University
Cambridge, Mass. 02138

ABSTRACT

Physa spelunca, *new species, is described. The ecology of the cave and adaptations of the* Physa *to the cave environment are discussed.*

While looking for crustaceans, particularly amphipods of the genus *Stygobromus*, in Lower Kane Cave, Wyoming, Dr. John R. Holsinger collected a number of blind *Physa* which he sent to us for identification. There were no *Stygobromus* in the cave and, in fact, other than the snails, all he found were a few clusters of oligochaetes, probably tubificids. He did not find anything in the spring outside the cave.

In his letter to us about the cave Dr. Holsinger wrote:

> "Lower Kane Cave is a solution cave developed in Paleozoic limestone. It's entrance is situated just above and east of the Big Horn River, about 12 miles east of Lovell and at an altitude of 3,000 feet. A stream flows through the cave and passes to the surface through a spring just below the entrance. The water from this spring flows directly into the Big Horn River. The source of the cave stream is a 'hot spring' at the far end of the cave, some 1,000 feet from the entrance. The stream temperature was 70° to 72° F [21-22° C] and that of the air in the cave was 78° to 80° F. The water was hard and had a strong sulphurous odor."

According to Dr. Holsinger, warm or hot cave streams are extremely rare. In fact the only other such cave with which he is acquainted is Warm River Cave in Allegheny County, Virginia. Brues (1932: p. 274-277) listed 19 species of gastropods occuring in hot springs and stated that *"Physa* seems to be the dominate type in thermal waters." In addition to thermal tolerance, species in this genus can tolerate brackish water, and they are usually the last of the snails to succumb when a stream becomes heavily polluted. Thus it is not surprising that *Physa* was the only snail found in Lower Kane Cave, particularly as the works of Henderson (1924, 1936) indicate that hydrobiids, species of which commonly occur in caves, are rare in this area. He did not list any hydrobiids in his Wyoming paper (1918) nor did Beetle (1961) report any from streams in the Big Horn Mountains.

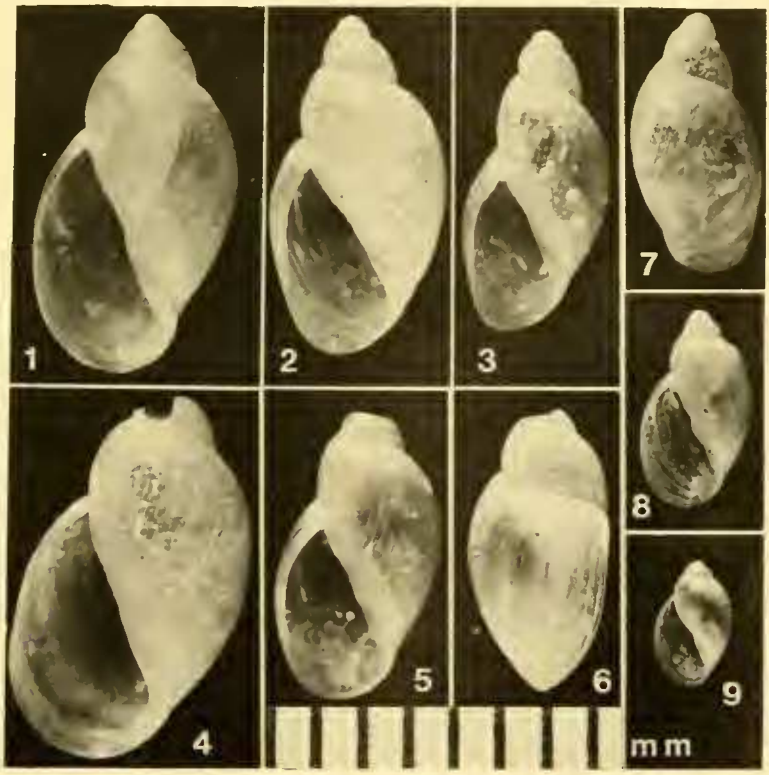
In Lower Kane Cave the *Physa* were common on the surface of small rocks submerged in rather fast-moving water well-back in the dark zone of the cave, some 800 to 900 feet from the entrance. Some were found on a colony of 'tubificid' worms in the sludge at the bottom of the stream.

In the United States the molluscan fauna of caves is rather limited and the majority of species found are readily identified with those living on the surface in the surrounding area. Cave specimens are usually somewhat smaller and have thinner, lighter-colored shells than their surface living relatives, but are otherwise similar (Hubricht, 1940b). Land snails living near the entrance or in the twilight zone are probably deposited in the cave on debris carried in by floods and it is doubtful if they are able to maintain themselves for many generations (Hubricht, 1941). Eighteen species and subspecies of land snails have invaded the dark zone of caves in Kentucky, Tennessee and Alabama (Hubricht, 1964). Six of them (5 *Helicodiscus* and *Carychium stygium* Call) are known only from these caves. They were found feeding on decaying plant material and the guano of cave crickets. When discussing the wide distribution of *Carychium stygium* in the Kentucky caves, Hubricht (1960) stated that the eyes of some specimens were somewhat reduced but he did not mention any other modifications to cave life.

Freshwater snails, especially Hydrobiidae, have become adapted to cave habitats and viable colonies are found well-back in the dark zone. A white, blind hydrobiid, *Fontigens tartarea*, was described by Hubricht (1963) from the stream in Organ Cave, Greenbrier Co., West Virginia, and Culver (1970) reported it from the "Greenbrier Caverns, the Hole (37° 56' 22" N; 80° 21' 12" W) and Martha's Cave." According to J. R. Holsinger (personal communication) large populations of troglobitic species of *Fontigens* have been found in the cave streams of the Applachians in Virginia and West Virginia but to date these have not been reported upon. Hubricht (1940a, 1971) described three unpigmented, blind *Amnicola* and *Antrobia culveri* (a new genus and species of blind Hydrobiidae) from caves in the Ozark Plateau. In 1950 he listed five species (two *Amnicola* and undertermined species of *Physa*, *Ferrissia* and *Musculium)* as living in the dark zone of these caves.

The small size of the species which have been able to successfully invade and survive in caves is undoubtedly a reflection of the scarcity of food in such habitats. No suspension feeding gastropods occur in such areas and among the bivalves only the Sphaeriidae are found.

In addition to being unpigmented and being one of the smallest species known, the *Physa* collected by Dr. Holsinger appear to be making modifications to cave life in the apparent reduction of the eye (see figure 19) proportionate increase in size of radular teeth (figs. 14-15), and an increase in the size of the embryo as evidenced by the size of the protoconch (Figs. 11-13). This large protoconch suggests that the young are more developed at the time of hat-



Physa spelunca *Turner and Clench, new species. FIG. 1, Holotype. FIGS. 2-9, Series of paratypes to show range of variation in the 75 specimens collected. FIG. 3, the most elongate. FIG 4, The largest, though lacking the spire. FIG. 6, Side view showing curvature of the lip. FIG. 7, Dorsal view of typical specimen. FIGS. 5 and 8, Specimens showing thickening of the columella area. FIG. 9, The smallest specimen collected.*

ching. Greater size would increase the mobility and search-range of the young, and a more fully developed radula would increase the range of food-particle size available to it. Both these factors would enhance its chances of survival in an environment where food is likely to be limited.

This increase in embryo size agrees with the findings of Poulson and White (1969) who worked with cave fish and cave beetles. They hypothesized that species which successfully invade caves tend toward smaller population size, lower reproduction rates, larger size at hatching, late maturity and longer life. These adaptions to a stable environment and low food supply suggest that this new species is opting for K selection as proposed by MacArthur and Wilson (1967). They are also in agreement with the Stability-Time hypothesis proposed by Sanders (1968) for many deep-sea infaunal species. Further research is needed to test this hypothesis for cave snails but to our knowledge this is the first time that such adaptations have been noted for any troglobitic mollusk.

The fact that epigean species of *Physa* are opportunistic probably allowed them to invade this hot spring cave. They are small-sized detritus feeders, capable of surviving under varying conditions of temperature, salinity and oxygen tension, as noted previously. These are characteristics that would preadapt them for the cave environment. Further adaptations, including the larger size of the young on hatching and the loss of eyes, are in agreement with the theories of Barr (1968). Cave mollusks are ideal organisms for evolutionary genetic studies such as those of Avise and Selander (1972) on cave fish of the genus *Astyanax*, but to date no work has been attempted along these lines. The large populations of *Fontigens* in the caves of Virginia and West Virginia mentioned by Holsinger would provide material for such a study.

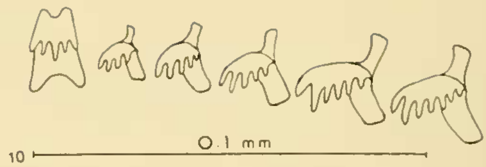


FIG. 10. Radular teeth of Physa spelunca *showing long denticles and apophyses. FIGS. 11-13. Comparative sizes of protoconchs in relation to adult size. FIG. 11.* Physa spelunca, *adults may reach about 11 mm in length. FIG. 12.* Physa virgata *Gould, adults reach 18 mm in length. FIG. 13.* Physa propinqua *Tryon, adults reach 21 mm in length.*

Physa spelunca, new species

Figs. 2-9, 11, 14, 16-17, 19

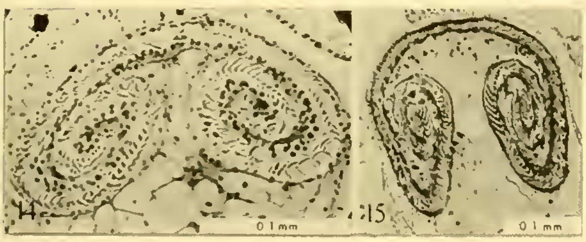
Description. Shell reaching 9 mm in length and 4.5 mm in greatest diameter (a somewhat larger, broken specimen has a body whorl length of 7.8 mm and a width of 5.0 mm which would give a proportional total length of about 11 mm). Shell highly polished, white with a very thin transparent periostracum; translucent, fragile and smooth. Sculpture consisting of exceedingly fine growth lines only, with no evidence of spiral sculpture. Whorls 4½ to 5, rounded, rapidly increasing in size; body whorl large, slightly shouldered; spire short, acute; spire angle about 65°. Sutures moderately impressed, aperture ear-shaped. Upper margin of thin, outer lip inserting on the body whorl well-below the periphery. Parietal callus thin to rather thick in older specimens. Columella oblique, curved, flattened and continuous with the outer lip. Protoconch of about 1¼ whorls, rounded, colorless and minutely malleated (see figure 11). Radula with v-shaped rows of teeth, typical of the genus, the formula being about 100-1-100 in the median portion (Fig. 10 and Fig. 14).

Anatomical notes. Only preserved specimens were available for study and these unfortunately were not in ideal condition. The animal was a uniform whitish, the tentacles short, broad and apparently lacking eyes at the base. Histological sections, however, showed a distinct eye cup but the retina was not developed and the lens was apparently lacking. A comparison of the eye of *Physa heterostropha* Say with that of *spelunca* is shown in Figs. 18-19. Digitations of the mantle were minute but this could have been a result of preservation.

The digestive system appears typical for the genus. The crop was packed with debris, minute sand grains and what appeared to be fungal hyphae. The reproductive system is typical for the genus, the male portion being of the 'Physodon' type as described and figured by Clampitt (1970). The penis sheath is about ⅔ the length of the praeputium, not constricted and is unpigmented. The praeputium has a slightly grayish tinge, and the praeputial gland is located in the lower half. The vas deferens is fine, about 4 times the length of the penis sheath, and about one fourth was buried in muscles of the body wall.

Measurements.

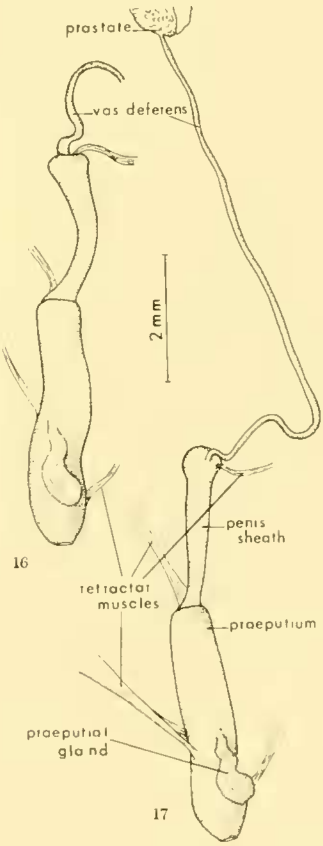
Length	Width
9.0 mm	4.5 mm
8.3	4.2
8.0	4.2
8.0	4.0
7.5	4.1
7.0	3.3
5.9	3.1
7.8	5.0 (broken specimen, body whorl only)



Transverse sections through posterior end of the odontophore of (FIG. 14) Physa spelunca *and (FIG. 15)* Physa heterostropha *Say showing the lateral incoiling of the radula when retracted. These specimens were preserved in alcohol and had not been properly fixed for histological work. The marked differences in shape may well result from differences in fixation and probably are of no taxonomic value. It is interesting to note that the radular teeth of* spelunca *from a specimen 6 mm long are proportionally larger than those of* heterostropha *from a specimen 12 mm long, suggesting that the cave specimens may be feeding on coarser material than surface living species.*

Type locality. Cave stream, about 800-900 feet from the entrance, in the dark zone, in Lower Kane Cave, near Kane, about 12 miles east of Lovell, on the east side of the Big Horn River, Big Horn County, Wyoming, at 3,000 feet elevation. Dr. John R. Holsinger, collector, June 18, 1969.

Repository of type specimens. Holotype, Museum of Comparative Zoology no. 280016; Paratypes MCZ nos. 280017-280019. Additional paratypes from the same locality are in the Museum of Zoology, Ohio State University;



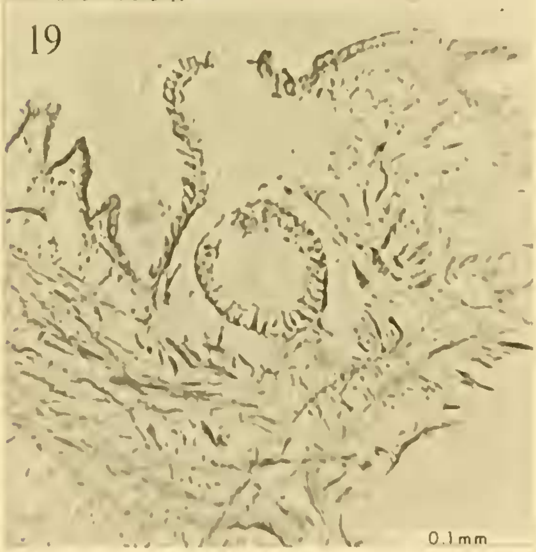
Two views of male reproductive system of Physa spelunca, *typical of the "Physodon" group. FIG. 16, Standard dorsal view. FIG. 17, Specimen turned to right to show muscle attachment.*

Museum of Zoology, University of Michigan; United States National Museum, Delaware Museum of Natural History and the Academy of Natural Sciences of Philadelphia.

Remarks. Physa spelunca is characterized by its transparent, colorless, highly-polished shell, its relatively blunt apex and large colorless protoconch (see figure 11). Based on the characters of the shell and the male reproductive system *spelunca* belongs to the 'Physodon' species group as modified from Baker (1928) by Clampitt (1970). The whorls are shouldered, the sutures impressed and the penial sheath of the male is not constricted (Figures 16-17). Baker (1928) described and figured the male reproductive system of *Physa integra* Haldeman and *P. walkeri* Crandall and placed them along with other species, the anatomy of which was unknown, in his group 'Physodon'. Clampitt (1970) reported that *P. michiganensis* Clench and *P. anatina* Lea also had the 'Physodon' type reproductive system and anatomical studies by Te (1973) in addition to confirming Baker's work on *integra*, showed that *P. virgata* Gould also belonged in this group. See Clampitt (1970) for discussion of the status of 'Physodon'.

18

19



Sections through the tentacles and eyes of Physa heterostropha *and* Physa spelunca. *Specimens of both species were preserved in alcohol and had not been properly fixed for histological work. Consequently the quality of the sections is poor but they are comparable. FIG. 18,* Physa heterostropha, *showing the lens and large heavily pigmented retina. FIG. 19,* Physa spelunca, *lacking both the pigmented retina and lens.*

Both *P. anatina* and *P. integra* have been reported from Wyoming (Henderson, 1918, 1936; Beetle, 1961) and both bear resemblances to *P. spelunca*. However, *spelunca* differs from them in being colorless, transparent and nearly glass-like; in lacking any indication of spiral sculpture or of thickened opaque axial lines indicating former margins of the lip. In addition, the columella of *spelunca* is oblique and curved rather than nearly straight, and the protoconch is white rather than amber-brown.

Physa propinqua Tryon, *P. gabbi* Tryon and *P. coniformis* Tryon, all closely related species from the northwestern states and British Columbia, are unknown anatomically but, on the basis of shell characters, could belong in 'Physodon'. Both *propinqua* and *coniformis* differ from *spelunca* in having fine axial and spiral sculpture, a straight columella, and in having the lip extended anteriorly well-beyond the base of the columella. *Physa gabbi* lacks spiral sculpture but has pronounced axial growth ridges, a strongly twisted columella, and more acute spire. *Physa virgata* Gould from Arizona which is known to have the 'Physodon' type anatomy also has both spiral and axial sculpture as well as a strongly twisted columella. All of these species have small dark protoconchs.

ACKNOWLEDGEMENTS

We are grateful to Dr. John R. Holsinger for the receipt of the specimens and for data on Lower Kane Cave; to George Te for discussions on *Physa* classification; to Samuel L. H. Fuller for preserved specimens of *Physa heterostropha* Say, and to Edward Allen for histological work.

LITERATURE CITED

Avise, J. C. & R. K. Selander. 1972. Evolutionary genetics of Cave-dwelling Fishes of the genus *Astyanax*. Evolution **26**: 1-19.

Baker, F. C. 1926. Nomenclatural Notes on American Freshwater Mollusca. Trans. Wisconsin Acad. Sciences Arts & Letters, **22**: 193-205.

Baker, F. C. 1928. The Freshwater Mollusca of Wisconsin, Part I. Gastropoda. Wisconsin Geol. and Nat. Hist. Survey Bull. **70**(1): 1-507, pls. 1-28.

Barr, T. C. Jr. 1968. Cave ecology and the Evolution of troglobites. Evolutionary Biology **2**:35-102 (Dobzhansky, Hecht, Steere, editors).

Beetle, D. 1961. Mollusca of the Big Horn Mountains. Nautilus **74**: 95-102.

Brues, C. T. 1932. Further studies on the Fauna of North American Hot Springs. Proc. American Acad. Arts & Sciences, **67** (7): 185-303.

Clampitt, Phillip T. 1970. Comparative Ecology of the Snails *Physa gyrina* and *Physa integra* (Basommatophora: Physidae). Malacologia **10** (1): 113-151, figs. 1-15.

Culver, D. C. 1970. Analysis of simple cave communities I. Caves as Islands. Evolution **24**:463-474.

Henderson, J. 1918. A Mollusk hunt in Wyoming. Nautilus, **32**: 40-47.

Henderson, J. 1924. Mollusca of Colorado, Utah, Montana, Idaho and Wyoming. University of Colorado Studies **13**: 65-223.

Henderson, J. 1936. Mollusca of Colorado, Utah, Montana, Idaho and Wyoming — Supplement. University of Colorado Studies **23**: 81-145.

Hubricht, L. Apr. 1940a. The Ozark Amnicolas. Nautilus **53**(4): 118-122.

Hubricht, L. July 1940b. The Snails of Ted Cave, Tennessee. Nautilus **54**(1): 10-11.

Hubricht, L. 1941. The Cave Mollusca of the Ozark Region. Nautilus **54**(4): 111-112.

Hubricht, L. 1950. The Invertebrate Fauna of Ozark Caves. National Speleological Society Bulletin **12**: 2 pages.

Hubricht, L. 1960. The Cave Snail, *Carychium stygium* Call. Trans. Kentucky Acad. Sci. **21**: 35-38.

Hubricht, L. 1963. New species of Hydrobiidae. Nautilus **76**(4): 138-140, pl. 8.

Hubricht, L. 1964. Land Snails from the Caves of Kentucky, Tennessee and Alabama. National Speleological Society Bulletin **26**(1): 33-35.

MacArthur, R. H. and E. O. Wilson. 1967. The Theory of Island Biogeography. Princeton University Press. 203 pages, 60 figures.

Poulson, T. L. and W. B. White. 1969. The Cave Environment. Science **165**(3897): 971-980, figs. 1-3.

Sanders, H. L. 1968. Marine Benthic Diversity: A Comparative Study. The American Naturalist **102**: 243-282.

Te, George A. 1973. A Brief review of the Systematics of the Physidae. Malacological Review **6**: 61.